

Department of Commerce
Technology Administration
National Institute of Standards and Technology
Working Capital Fund
SUPPLEMENTAL INCREASE FOR FY 2002

National Building and Fire Safety Investigation of the World Trade Center Disaster (+\$16,000,000 reimbursable agreement from FEMA as part of its FY 2002 supplemental appropriations) – To investigate the building construction, the integrity of the materials used, and all the technical conditions that combined to cause the World Trade Center (WTC) disaster – the worst-ever building disaster in human history. A growing number of technical experts, families of victims, and elected officials have called for a broad and detailed investigation to address these concerns. The funding for a NIST-led technical investigation of the WTC collapses will be provided by a reimbursable agreement from the Federal Emergency Management Agency (FEMA). However, it will be an independent and comprehensive NIST-led technical investigation under NIST's existing legislative authorities to initiate and conduct structural and fire investigations. NIST currently expects to complete the investigation and issue a final report in 24 months. The implementation of the results of the investigation will be critical to restore public confidence in the safety of tall buildings nationwide, enhance the safety of fire and emergency responders, and better protect people and property in the future. In addition, it will support a construction-industry led roadmapping effort to reflect changed priorities for development and deployment of safety and security standards, technology, and practices, and a complementary effort to deliver and deploy new/improved practical guidance, tools, and technical assistance to speed economic recovery within the industry following disasters.

Problem Magnitude and NIST Role:

The United States witnessed unprecedented death and destruction on September 11, 2001 compared with any prior accident, natural disaster, or terrorist/war attack – with the exception of the civil war battle at Antietam, MD, in which 3,654 lives were lost in a day. Never before have over 350 emergency responders lost their lives in a single incident. Engineers, emergency responders, and the general public did not anticipate, and much less prepare for, the dramatic collapse of buildings occupied and in everyday use.

“The Skyscraper Safety Campaign: A Project of Parents of Firefighters” is pressing to see that a “Federal, Independent Blue Ribbon Panel be convened immediately to study the building construction, the integrity of the materials used, and all the conditions that combined to cause this tragedy.” The group, led by Mrs. Sally Regenhard, the mother of a firefighter who died in the collapse,

represents 160 family members of fallen firefighters. This campaign is supported by the 2,800 member "Give Your Voice" WTC victim's association.

A growing number of technical experts nationwide and elected officials from the New York region have joined with the families of the victims to ask for a broad and detailed investigation, well beyond the scope of a building performance study initiated and funded by FEMA. FEMA has requested NIST to take over major portions of the technical investigation given NIST's legislative authorities to conduct structural and fire investigations [P.L. 99-73, Sec. 7 or 15 U.S.C. 281a; P.L. 93-498, Sec. 16, (a), (3)] and its extensive prior experience in conducting such investigations.

NIST has received policy approval from the U.S. Department of Commerce to initiate and conduct an independent and comprehensive "National Building and Fire Safety Investigation of the World Trade Center Disaster" under its existing legislative authorities. The reimbursable funds from FEMA's FY 2002 supplemental appropriations are required for NIST to undertake the investigation. NIST currently expects to complete the investigation and issue a final report in 24 months.

The implementation of the results of the investigation will be critical to restore public confidence in the safety of tall buildings nationwide, enhance the safety of fire and emergency responders, and better protect people and property in the future. In addition, the investigation will be extremely valuable in establishing the probable technical causes of the disaster, deriving the lessons from the WTC disaster, and identifying needed improvements to building and fire standards, codes, and practices and to the safety of tall buildings nationwide. To cite one example, the February 4th issue of "Crain's New York Business" reports that an increasing number of tenants are leaving the Empire State Building, which is again the tallest building in New York City, because of fears of another terrorist attack. Anecdotal evidence also suggests that building vacancy rates have doubled in Manhattan, despite the 15 million square feet of space that was lost on September 11th.

The results of the investigation will also underpin and guide future work to develop and disseminate immediate guidance and tools to assess and reduce vulnerabilities, and produce the technical basis for cost-effective changes to national practices and standards. A private sector coalition – representing the key industry, standards, codes, and professional organizations – has worked with NIST to establish and partially fund a comprehensive response program to meet these longer-term needs. The goal of the longer-term program is to produce cost-effective retrofit and design measures and operational guidance for building owners and emergency responders.

The specific consequences of not carrying out this investigation and the broader follow on work include: loss of valuable perishable data that must be collected and archived immediately, incomplete and/or lack of objective assessments of building failures and lessons for the future, unknown vulnerability of existing building stock and lack of vulnerability assessment tools, lack of operational guidance for building owners and emergency responders, continuing risk in the performance of fire protection systems and technical

barriers to innovation, unreliable test methods, outdated design codes and standards for new construction and lack of similar guidance to retrofit existing buildings, and risks associated with ad hoc and prescriptive changes to building codes that lack technical basis.

NIST's Building and Fire Research Laboratory (BFRL) is the only federal laboratory dedicated to building and fire safety and security, and these communities expect BFRL to provide the leadership for this national investigation. BFRL has extensive leadership experience in prior investigations, relevant standards and codes organizations, other national programs and initiatives, key industry and interagency groups, and international organizations. BFRL-led work has achieved broad impacts on standards and industry practices and it has a world-class professional staff. Also, NIST's Materials Science and Engineering Laboratory (MSEL) has extensive experience in materials characterization and testing, including steels used in construction and thermally protective coatings.

Proposed NIST Technical Program

The primary objectives of the independent and comprehensive NIST-led technical investigation of the WTC disaster are to:

- Determine technically, why and how the buildings, WTC 1 and 2, and possibly WTC 7, collapsed following the plane impacts.
- Determine why the injuries and fatalities were so low/high, including all technical aspects of fire protection, response, evacuation, and occupant behavior and response.
- Determine whether state-of-the-art procedures and practices were used in the design, construction, operation, and maintenance of the WTC buildings as these factors related to the collapse of the buildings and associated injuries and fatalities.
- Determine whether there are new technologies/procedures emerging that could/should be employed in the future to reduce the potential risks of such collapse and loss of life and property.
- Identify building and fire codes, standards, and practices that warrant revision.

The NIST investigation will focus primarily on World Trade Center Buildings 1 and 2 (the Twin Towers) for several reasons. First, the collapse of the Towers was the triggering event that caused much of the collateral damage to the adjacent properties and the loss of life to fire and emergency responders. Second, many structural and fire protection design features and construction details found in the Towers are widely used in the building construction industry. Third, to study procedures and practices used to assess the safety of innovative structural systems and building designs not covered by existing building codes or prior in-use experience, as was the case for the twin towers, and whether such practices are adequate to detect and remedy inherent vulnerabilities. Fourth, to study procedures and practices used to provide adequate structural reserve capacity to resist abnormal loads (e.g. blast, explosion, impact due to aircraft or flying debris from tornadoes, accidental fires, and faulty design and construction), especially those that can be anticipated prior to construction (such as the impact from the Boeing 707). And lastly, the Twin Towers will provide the opportunity to study the effectiveness of fire protection and firefighting technologies and practices for tall buildings, including emergency mobility

and egress, and communication systems. Besides the Towers, the investigation will possibly consider examining WTC Building 7, which was adjacent to the towers and collapsed later in the day on September 11.

NIST will ensure a totally independent technical investigation both in planning and conducting the investigation and in publishing its findings and recommendations. The technical issues are highly complex, unique, and subtle. The focus of the investigation will be on creating new technical and/or scientific knowledge. The technical work will be thorough, deliberate and rigorous. The results will be objective and unbiased. NIST will provide timely and open public disclosure within legal bounds on the progress of the investigation. Non-technical issues will be outside the scope of the NIST investigation. NIST will make no findings of fault or responsibility. It will make no determination as to behavior or negligence of any individual or organization.

The technical approach of the NIST investigation will include the following phases:

- **Data Collection:** inputs from the Port Authority of New York and New Jersey (PANYNJ) and local authorities; building and fire protection design, plans, and specifications; construction, maintenance, operation records, building renovations and upgrades; video and photographic data; field data; interviews; emergency response records including audio communications; and other records.
- **Analysis and Comparison of Building and Fire Codes:** analysis and comparisons of codes and standards then and now, and specifications used for WTC buildings.
- **Identification of Technical Issues and Major Hypotheses Requiring Investigation:** opportunity for public input (e.g., open forum; website; federal register notice); convene expert panels to solicit input (experts in structural and fire protection engineering; experts in construction, maintenance, operation and emergency response procedures of tall buildings); findings and recommendations of the FEMA-funded Building Performance Assessment Team (BPAT) study; analyze inputs and establish priorities; and review and approval by independent Technical Review Panel.
- **Collection and Analysis of Forensic Evidence:** structural steel, material specimens and other forensic evidence to the extent they have been collected or are otherwise available; metallurgical and mechanical analysis of steel to evaluate quality and estimate maximum temperatures; and analysis of fire and elevator control panels.
- **Modeling, Simulation, and Scenario Analysis:** aircraft impact on structures and estimate damages to interior and core structure and residual capacities; role of jet fuel and building contents in resulting fire; fire dynamics and smoke movement; thermal effect on structures and the effect of fireproofing; structural response under fire and the effect of connections, flooring system, core and exterior columns, and the overall structural system; occupant behavior and response including influence of communications and barriers to egress; evacuation issues including egress, analysis of control/fire panels, emergency response, and communications; analysis of fire protection system design and vulnerability; and analysis of structural collapse mechanisms including evaluation of system vulnerability to progressive collapse and fires, scenario analysis to test hypothesis and address technical issues, and establishing bounds for probable technical causes.

- **Testing to Demonstrate Scenarios and Failure Mechanisms:** small and some real-scale re-creation tests to provide additional data and verify simulation predictions, especially effect of fires (e.g., use and adequacy of standard fire ratings, behavior of connections and assemblies).
- **Preparation of Interim and Final Reports:** review and approval by specially appointed and independent Technical Review Panel; and dissemination via published reports, web, and media.
- **Dissemination and Deployment of Findings:** develop and disseminate proposed changes to codes and standards based on findings; and participate with industry in their adoption and acceptance into codes and standards.

The NIST investigation will use world-class technical expertise from both within and outside NIST. External experts will be drawn from academia and practice and used on an as-needed basis in various phases of the investigation. In addition, the NIST Director will appoint a 5-7 member Technical Review Panel to support the Lead Technical Investigator at NIST. This Panel will serve the function of a “Federal, Blue Ribbon Panel” that has been proposed by experts, the families of victims, and elected officials. Members of the Panel will be nationally respected authorities in broad fields, possess world-class technical expertise and experience, and have a reputation for independence, objectivity, and impartiality. The primary focus of the Panel will be to ensure that the right things are being done and to provide an independent review of the technical aspects of the investigation. NIST will consult and maintain liaison with Federal and local authorities that can assist in conducting this investigation.

NIST will also support a construction-industry led roadmapping effort to reflect changed priorities for development and deployment of safety and security standards, technology, and practices. It will support the effective delivery and deployment of new/improved practical guidance, tools, and technical assistance to better prepare facility owners, contractors, designers, and emergency personnel to respond to future disasters and to speed economic recovery within the industry following disasters. This effort will complement and support parallel efforts of technical organizations to improve standards, codes, and practices. Key industry organizations leading this effort will include the Construction Industry Institute, the FLATECH Consortium, the Civil Engineering Research Foundation, and the National Institute of Building Sciences.

NIST will establish a secretariat to support the investigation. NIST recognizes that there will be significant public and media interest in the investigation. NIST will assign a spokesman to provide press announcements and media briefings during the course of the investigation. NIST will also provide information via reports and briefings to DoC, OMB and Congress at their request. The NIST secretariat will provide other essential functions, including records management and data archives, liaison with Federal and local authorities, legal counsel, and support services.

Performance Measures: Outputs

At the proposed funding level, NIST will generate the following outputs:

National Building and Fire Safety Investigation of the World Trade Center Disaster	
Technical Area	Outputs
Data Collection	<ul style="list-style-type: none">• Report(s) on Data Collection Phase of the Investigation.
Building & Fire Codes	<ul style="list-style-type: none">• Report(s) on Analysis and Comparison of Building and Fire Codes Phase of the Investigation.
Technical Issues & Major Hypotheses	<ul style="list-style-type: none">• Report(s) on Identification of Technical Issues and Major Hypotheses Requiring Investigation Phase of the Investigation.
Forensic Evidence	<ul style="list-style-type: none">• Report(s) on Collection and Analysis of Forensic Evidence Phase of the Investigation.
Modeling, Simulation, & Scenario Analysis	<ul style="list-style-type: none">• Report(s) on Modeling, Simulation, and Scenario Analysis Phase of the Investigation.
Re-creation Testing	<ul style="list-style-type: none">• Report(s) on Testing to Demonstrate Scenarios and Failure Mechanisms Phase of the Investigation.
Technical Findings and Recommendations	<ul style="list-style-type: none">• Interim and Final Reports on the Technical Findings and Recommendations of the Investigation, including probable technical causes of the disaster.
Dissemination and Deployment of Findings	<ul style="list-style-type: none">• Dissemination and Deployment of Findings via proposed standards and codes changes and participation with industry in their adoption and acceptance into codes and standards.
Construction Industry Roadmap	<ul style="list-style-type: none">• Report on construction industry roadmap to reflect changed priorities for development and deployment of safety and security standards, technology, and practices.
Best Practices Guidance and Technical Assistance	<ul style="list-style-type: none">• Report(s) on practical guidance, tools, and technical assistance to assure effective deployment of new/improved methods into practice and speed economic recovery within the construction industry following disasters.

Performance Measures: Outcomes

At the proposed funding level, NIST will generate the following outcomes:

- Authoritative and independent technical account of:
 - what happened and why regarding the collapses of WTC 1 and 2, and possibly WTC 7, including the probable technical causes of the disaster.
 - why the injuries and fatalities were so low/high, including occupant behavior and response and evacuation procedures actually experienced in the WTC.
 - whether state-of-the-art procedures were used in the design, construction, operation, and maintenance of the WTC buildings.
 - whether there are new technologies/procedures emerging that could/should be employed in the future to reduce the potential risks of such collapses and loss of life and property.
- Identification of building and fire codes, standards, and practices that warrant revision.
- Bringing world-class engineering practitioners and researchers together to address highly complex technical issues.
- Established construction industry priorities for safety and security standards, technology, and practices.
- Practical guidance, tools, and technical assistance to speed economic recovery within the construction industry following disasters.

Examples of the potential impact of this effort are wide ranging, for example:

- Restore public confidence in tall buildings nationwide.
- Enhance safety of firefighters and emergency responders.
- Better protect people and property in the future.
- Enhanced homeland security and reduced vulnerability via saved lives and costs:
 - Replace guesses with fact and supporting analysis.
 - More intelligent decisions for future (a) retrofit and design, and (b) emergency planning and response.
 - Shape priorities for improvements needed to standards, codes, and practices, and supporting research.
- Speedier economic recovery and renewed growth following major disasters.
 - Practical guidance, tools, and technical assistance for construction industry.